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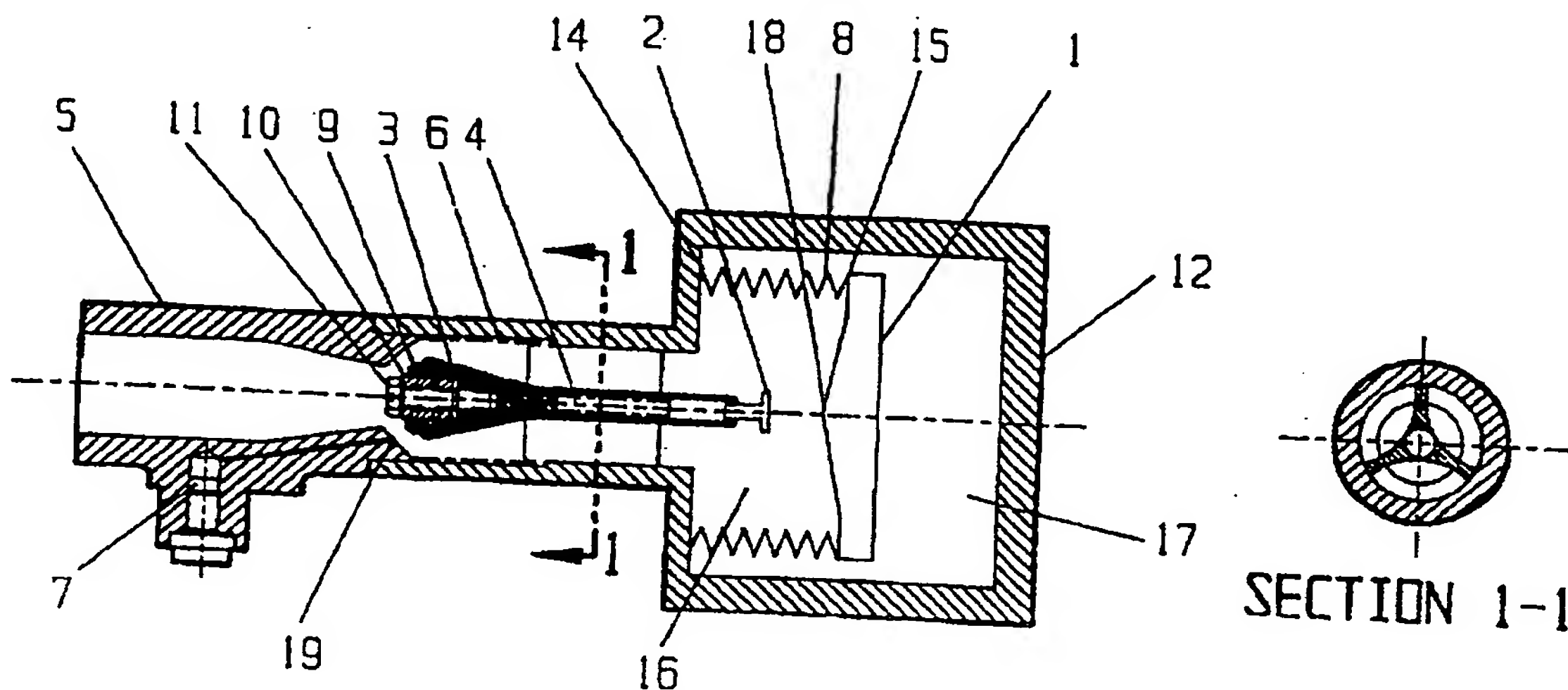
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(57) Abstract-

An improved hydraulic accumulator is introduced wherein a valve mechanism (3) is used to seal a hydraulic fluid before the pressure charged piston (1) reaches the end of the accumulator to minimize the loss of compressed gas by eliminating the pressure differential when the piston (1) is fully extended, thereby prolonging the fatigue life of the accumulator vessel. Reduction of the pressure loading on the vessel will also prolong the life of the piston seals and metal bellows (8) effectively extending the accumulator life and effectively allowing design for weight reduction and preservation of the integrity of the complete hydraulic or pneumatic system.

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A NOVEL ACCUMULATOR

Background & Field of the Invention

1. Field of the Invention

When hydraulic accumulators discharge their working fluid, the dynamic gas/fluid separating device, consisting of a bellows or piston, is placed in a condition of high steady state stress. This stress is due to the force created by the gas pre-charge pressure present on the side of the separator and the actual lower-working pressure on the expelled fluid side. Further, high point contact loads may exist where the separator mechanically stops on the accumulator vessel structure.

The foregoing conditions must be considered by the designer, especially in high performance driven applications where weight of the unit and operating life are major factors. One factor must be compromised with the other.

2. Description of Prior Art

a) U.S. Patent No. 2,745,357 introduces an aircraft hydraulic system with an improved pressure type reservoir.

b) U.S. Patent No. 4,601,369 describes a pressure vessel.

c) U.S. Patent No. 4,852,615 teaches a hydropneumatic accumulator with two chambers.

d) U.S. Patent No. 4,959,958 shows a hydraulic

1 g) U.S. Patent No. 5,036,661 shows a regulated level
2 accumulator for liquid under high pressure.
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Summary Of The Invention

5 A valve mechanism is introduced in conjunction with an
6 accumulator piston and vessel, the piston acting as a
7 separator to separate liquid from gas components. The
8 valve mechanism is so designed as to sense the relative
9 position of the piston.

10 The valve mechanism will limit the expelled fluid volume of
11 the accumulator to obtain pressure equilibrium across the
12 piston (separator). This action of the valve mechanism
13 reduces the pressure differential and forces across the
14 piston causing the high, steady stress levels of the
15 piston, eliminating the high contact loads on the static
16 housing.

17 The valve mechanism will limit the expelled fluid near the
18 time of complete discharge such that the fluid pressure
19 will not be below the gas pre-charge pressure. This
20 mechanism may be used in a static vessel, dynamic piston
21 (separator) or as a separate system interfacing with the
22 accumulator.

23 Localized high stressed concentrations in either the fluid
24 separator or the surrounding shell resulting from the
25 piston (separator) being bottomed on the hydraulic end of
26 the shell causes fatigue and a short life span for the
27 shell.

28 Accumulators are used for two separate functions in the
29 standard hydraulic system. The first is to store energy in
30 the form of compressed gas and hydraulic fluid. The second
31 is to absorb pressure spikes which occur when a component
32 in the hydraulic system actuates or performs work. Both of
33 these applications require the use of a compressible fluid
34 (gas, i.e. nitrogen, helium, air etc.) on one side of a

1 separator and a non-compressible fluid (hydraulic oil) on
2 the other side. When the hydraulic system pressure drops
3 below the pre-charged pressure of the gas side, the
4 separator will move in the direction of the hydraulic side,
5 displacing stored hydraulic fluid into the system as
6 required. When the hydraulic system is shut down, the
7 separator goes to the full stroke stopped position and you
8 are left with the full pre-charge pressure being applied to
9 the area of the separator creating a force which acts on
10 the separator and thereby inducing a stress in this member.
11 When fully bottomed, this load is also applied to through
12 the stopping mechanism which in turn creates a localized
13 high stress area in the shell.

14 With both of the above, the noted stresses can be addressed
15 by material selection and/or material thickness and
16 physical geometry. Typically, both of these approaches can
17 add considerable weight to the final design solution and,
18 in many cases, reduce the entire overall performance, as a
19 result of the weight penalty, of the entire operating
20 system.

21 The present approach is to capture enough fluid in the
22 hydraulic side of the accumulator to keep the separator
23 from just short of its bottoming position, thereby
24 equalizing the pressure on both sides of the separator
25 which will, in turn, reduce the stress levels attributable
26 to the pressure loading of the separator. This will also
27 prevent the separator from physically bottoming on the
28 hydraulic shell, resulting in a uniformly distributed
29 pressure loading of the hydraulic shell.

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3 BRIEF DESCRIPTION OF THE DRAWINGS

4 Figure 1. Cross section of the accumulator using
5 bellows as a separator of gas & fluid chambers.

6 Figure 2. Cross section of alternative accumulator
7 design using piston as a separator of gas & fluid chambers
8 showing poppet in sealed position.

9 Figure 3. Cross section of alternative accumulator
10 design using piston as a separator of gas & fluid chambers
11 showing poppet in the open position.

12 Figure 4. Cross section detail of tail end of poppet
13 in the open position.

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3 DETAILED DESCRIPTION OF THE PREFERRED
4 EMBODIMENT OF THE INVENTION
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6 The first embodiment of the invention is shown in Figure 1
7 and Figure 4 and will now be described.

8 This embodiment is the preferred embodiment of the
9 invention. It is important to note that the poppet
10 described in Figures 1, 2, 3, 4, 6, 9, 10 and 11 is the
11 point of the invention. The addition of this poppet to the
12 accumulator design permits control of the expelled fluid
13 such that the fluid side pressure will not be below the gas
14 pre-charge pressure. This valve sealing mechanism will
15 allow the piston to travel to a position of pressure
16 equilibrium and will prevent contact loads from being
17 transferred to the vessel permitting the sealing prior to
18 the piston achieving the fully stroked position,
19 eliminating contact stress with the vessel.

20 Referring to Figure 1, as the pressure in the hydraulic
21 system exceeds the gas pressure, the return spring (6) will
22 apply force to the valve mechanism to return it to an open
23 position. The return spring (6) is attached to poppet (3)
24 which when opened allows hydraulic flow into the liquid
25 chamber (16) compressing the gas in the gas chamber (17) of
26 the accumulator chamber (12). This hydraulic flow expands
27 the bellows (8) moving the protruding center (18) of the
28 rear wall of the piston (1) away from the contact pin (2)
29 of the poppet (3) compressing the gas in the gas chamber
30 (17).
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1 Referring to Figure 2, as the piston (1) strokes to a
2 predetermined position or gas volume in the gas chamber
3 (17) its protruding center (18) contacts the contact pin
4 (2) which then compresses the contact pin spring (4)
5 forcing the poppet (3) to seal the fluid chamber with the
6 poppet seal (9) held by seal retainer (10) with the seal
7 retainer screw (11) to the poppet (3) seals the fluid
8 chamber by coming into contact with the shoulders (19) of
9 the valve seat (5). On the lower portion of the valve seat
10 (5) is a pressure test port (7) which is used to check the
11 hydraulic pressure of the system and whether the poppet
12 seal (9) is properly sealed. At full discharge of the
13 accumulator, the hydraulic pressure between the poppet seal
14 (9) and the piston (1) in the liquid chamber (16) equals
15 the pressure in the gas chamber (17).

16 An alternative embodiment of the invention is demonstrated
17 in Figure 2 and Figure 3. Therein, bellows are replaced by
18 the piston (1). The piston (1) acts as a separator between
19 the liquid chamber (16) and the gas chamber (17) with the
20 piston (1) flush with the interior walls of the accumulator
21 housing (12), sealed by "O" ring (13). The principles and
22 operation of the accumulator so designed is the same with
23 the exception of the replacement for the bellows (8).

24 Figure 2 shows the poppet seal, in the closed position,
25 with the (9) seal and seal retainer (10) resting on the
26 shoulders (19) of the seal valve to stop the fluid flow to
27 the liquid chamber (16) when the pressure in the liquid
28 chamber (16) is equal to the pressure in the gas chamber
29 (17).

30 Figure 4 is a cut away portion of the poppet (3) in its
31 open position to allow fluid to flow into the liquid
32 chamber (16) wherein the return spring (6) is acting in

1 opposition to compression spring (4) pushing out the
2 contact pin (2) to push out piston (1) to compress the gas
3 in the gas chamber (17).

4 Also shown are the seal retainer (10) and seal (9) on the
5 poppet (3) held together by seal retainer screw (11) away
6 and from the shoulder away and from the shoulders (19) of
7 the seat valve (5) in the open position.

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3 DETAILED ADVANTAGE & UNIQUE POINTS OF THE INVENTION

4 The point of present invention is the introduction of the
5 poppet valve design to seal the fluid chamber prior to the
6 piston reaching the fully stroked position. This unique
7 design prevents the piston from being subjected to the full
8 pre-charge load during cycling.

9 An additional benefit of this valve mechanism is the
10 establishment of an equilibrium position with the spring
11 loaded poppet valve design providing an integral pressure
12 relief feature due to pressure changes associated with
13 temperature changes in the system.

14 The foregoing features introduced by this unique poppet
15 valve system decrease fatigue and wear and tear on the
16 system, thereby increasing the longevity of the
17 accumulator.
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WHAT IS CLAIMED IS:

1. An accumulator comprising:
 - a) a hollow housing;
 - b) a bellows located inside the housing, said bellows including a bellows body having a first end and a second end, said first end being secured to the housing and second end being allowed to move in an axial direction of the housing;
 - c) a bellows attachment to a piston for closing the second end of the bellows body;
 - d) a liquid chamber defined by the inner face of the bellows and filled with a liquid;
 - e) a gas chamber defined by the outer face of the bellows body and said piston and charged with a compressed gas;
 - f) a tube seat having a liquid flow port communicating with the liquid chamber and allowing liquid in the liquid chamber to pass when the bellows is compressed or expanded and a first set of shoulders at forward end of said tube seat;
 - g) a self-seal mechanism comprising a shaft with an arrow-shaped poppet having an outer tail end in an axial position opposite a contact pin directly opposite said rear protruding center of said piston which has a second set of shoulders which comes into contact with said first set of shoulders on said forward end of tube seat when said pin is compressed when gas in said chamber forces said piston to make contact with said contact pin;
 - h) said contact pin in the said shaft of said arrow-shaped poppet connected to a compressible inner spring to force an

outer spring attached to said outer tail end of said poppet in an axial position opposite said contact pin to be compressed when said piston is in contact with said contact pin pushing said outer tail end of poppet to seat on said tube seat with a seal retainer and seal on said tail end of said poppet to cause liquid flow to stop flowing into liquid chamber;

i) said self-seal mechanism for closing the said liquid flow port when the pressure changes of the compressed gas in the gas chamber forces the bellows to be deformed in its axial direction to a pre-determined extent, part of the liquid in the liquid chamber being confined to a region inside the bellows when the said self-seal mechanism is closed by the action of the said piston coming into contact with said contact pin of said poppet;

j) said second set of shoulders of said shaft having a seal retainer and seal which comes into contact with and sits on said first set of shoulders of said tube seat to prevent liquid flow into the now sealed liquid chamber;

k) said self-seal mechanism also comprising outer spring and will compress in an axial direction opposite said inner spring which will compress said inner spring allowing hydraulic flow pressure from the liquid to open said seal and permit bellows to expand pushing the piston forward to compress gas in said gas chamber.

2. An accumulator comprising:

a) a hollow housing;

b) a piston inside said housing; said piston being flush with interior wall of said housing sealed by an "O" ring;

c) said piston separating a gas chamber from a liquid chamber;

d) said liquid chamber defined by interior wall of said

housing and rear side of said piston;

e) said gas chamber defined by the interior wall of said housing and forward side of said piston and charged with compressed gas;

f) said piston having a protruding center portion on its rear wall in liquid chamber;

g) a tube seat having a liquid flow port communicating with the liquid chamber and allowing liquid in the liquid chamber, said tube seat having a first set of shoulders at a forward end of said tube seat;

h) a self-seal mechanism comprising a shaft with an arrow-shaped poppet having an outer tail end in an axial position opposite a contact pin directly opposite said rear protruding center of said piston which has a second set of shoulder which come into contact with said first set of shoulders on said forward end of the tube seat when said pin is compressed when gas in said chamber forces said piston to make contact with said contact pin;

i) said contact pin in the shaft of said arrow-shaped poppet is connected to a compressible inner spring to force an outer spring attached to said outer tail end of said poppet in an axial position opposite said contact pin to be compressed when said piston is in contact with said contact pin pushing said outer tail end of poppet to seat on said tube seat with a seal retainer and seal on said tail end of said poppet to cause liquid flow to stop flowing into said liquid chamber;

j) said self-seal mechanism for closing the said liquid flow port when the pressure changes of the compressed gas in the gas chamber forces the piston to move in the axial direction to a predetermined extent, part of the liquid in the liquid chamber being confined to a region inside the

accumulator when the self-sealed mechanism is closed by the action of the said piston coming into contact with said contact pin of said poppet;

k) said second set of shoulders of said shaft having a seal retainer and seal which comes into contact with and sits on said first set of shoulders of said tube seat to prevent liquid flow into the now sealed liquid chamber;

l) said self-seal mechanism also comprising outer spring which will compress in an axial direction opposite said inner spring and will compress said inner spring allowing hydraulic flow pressure from the liquid to open said seal and permit the liquid chamber to be pressurized pushing the said piston forward to compress gas in said gas chamber.

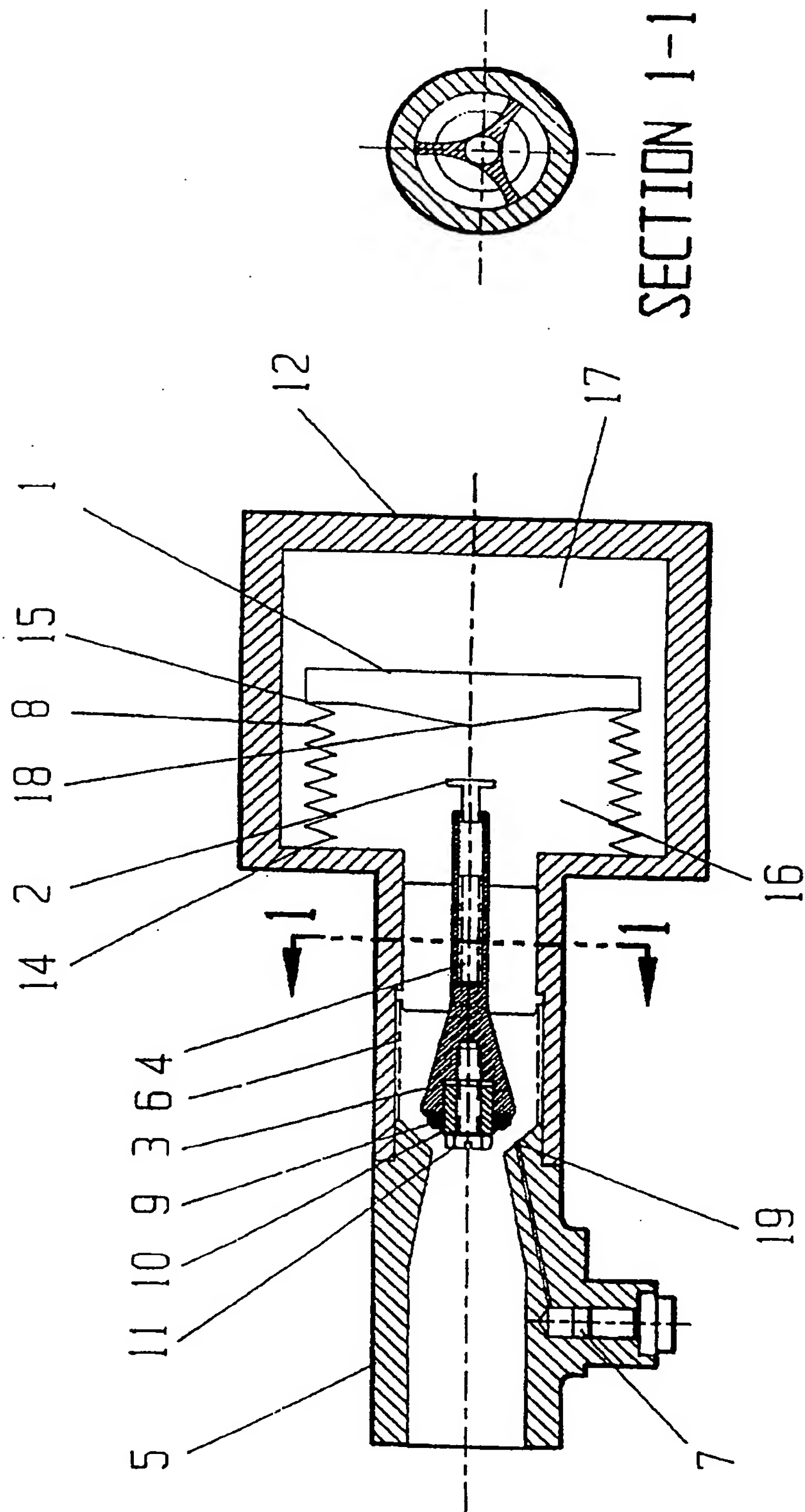


FIG. 1

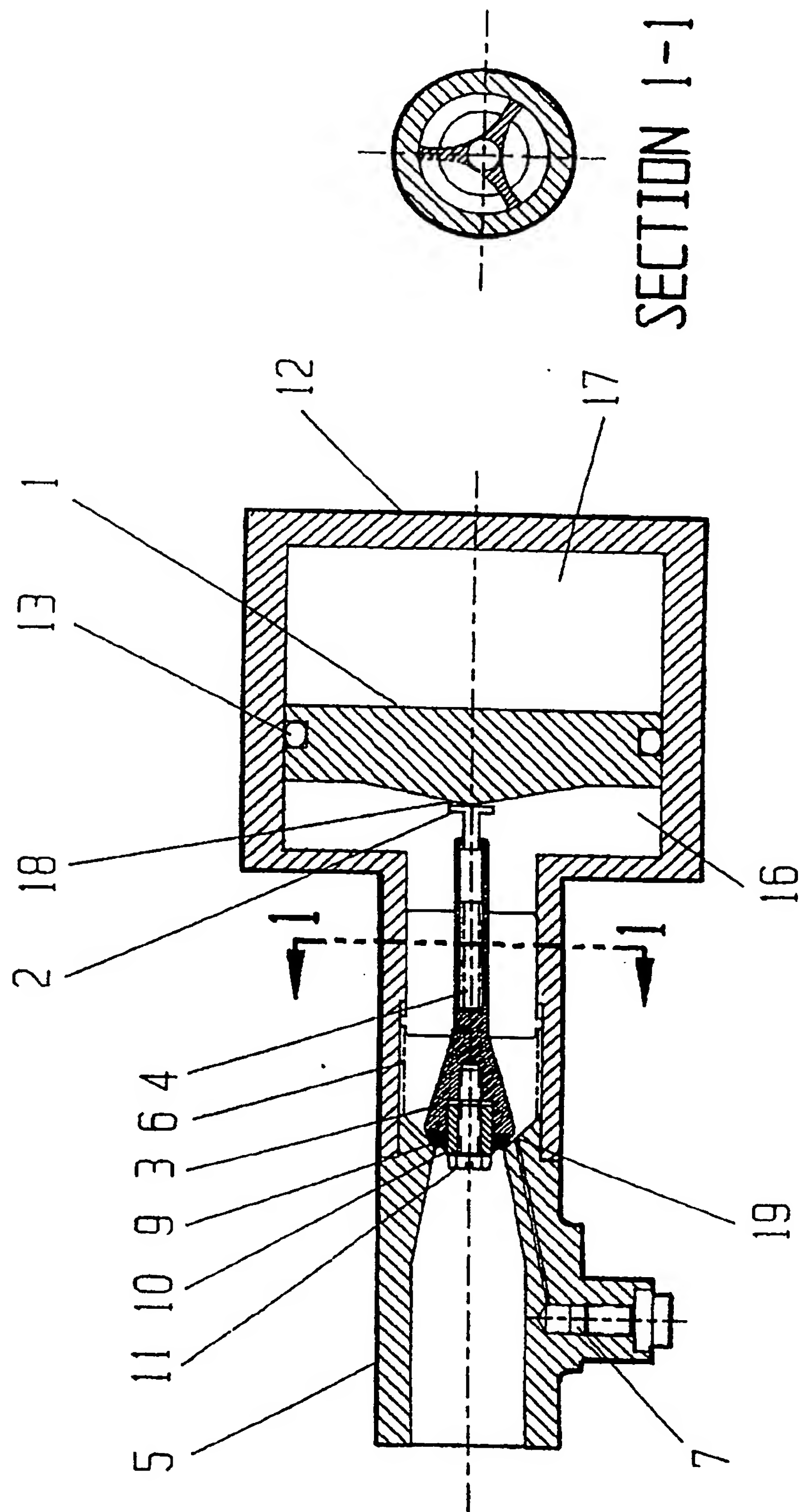


FIG. 2

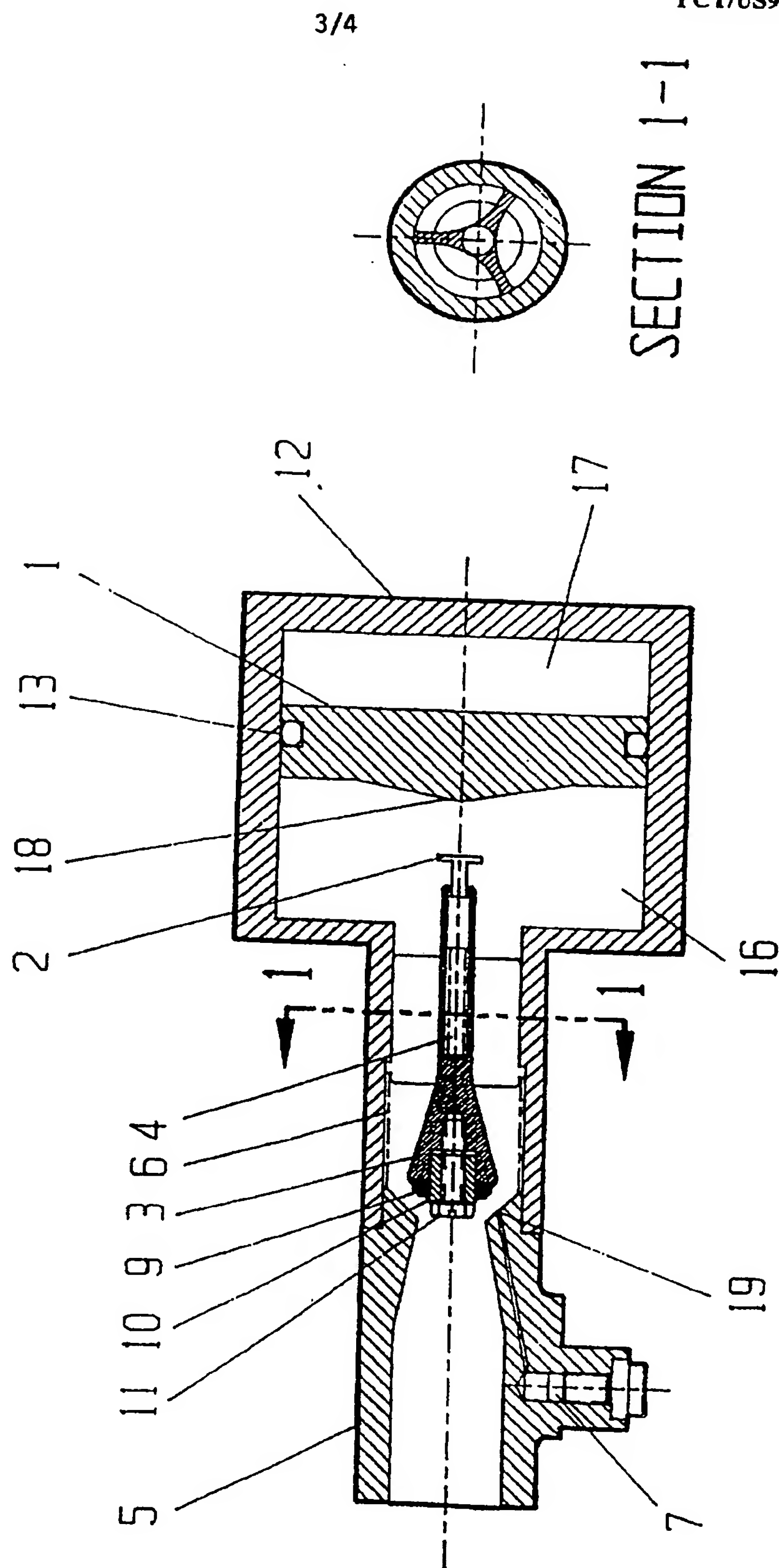


FIG. 3

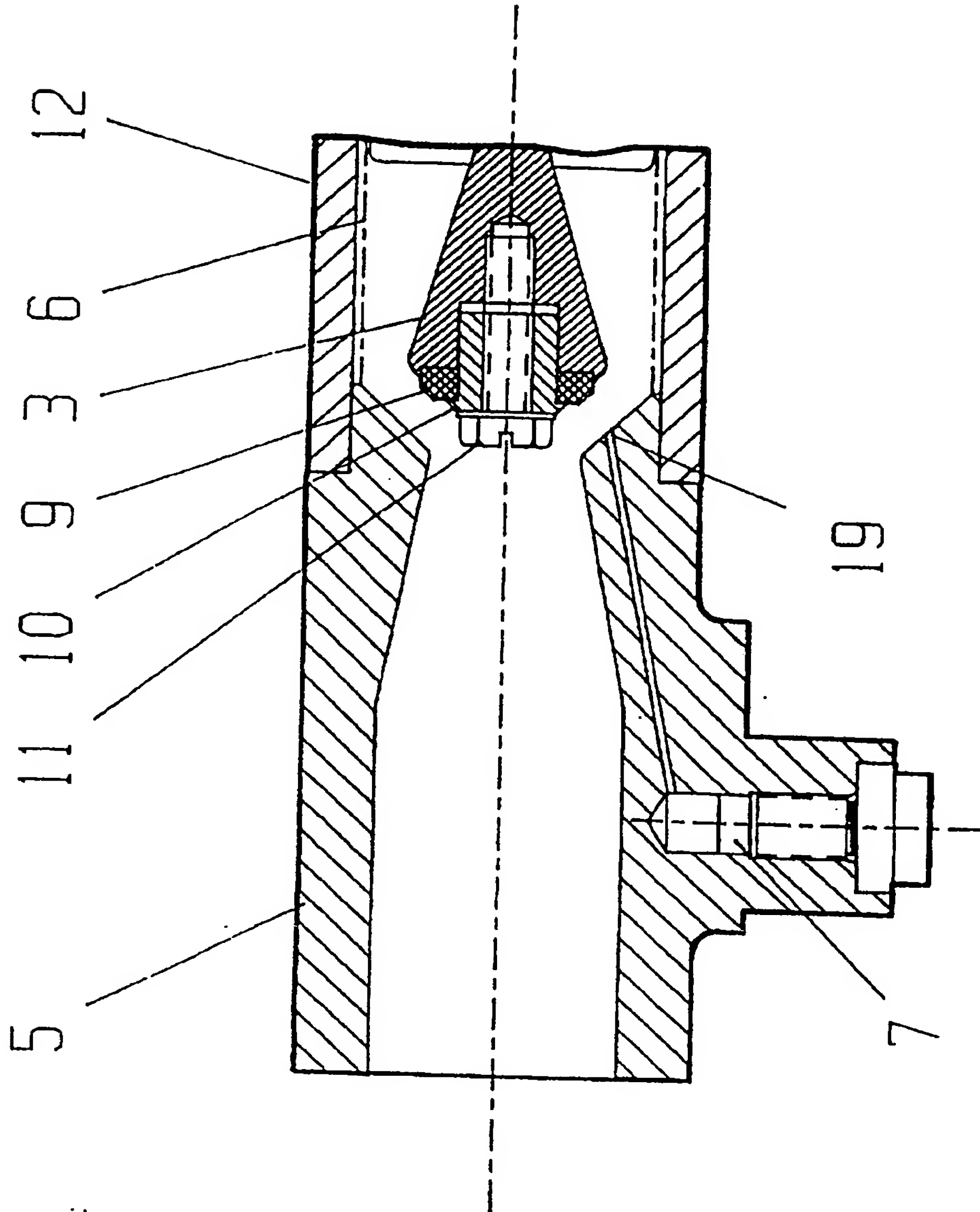


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/09677

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : F16L 55/04

US CL : 138/31

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 138/31, 30, 26; 220/721

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3,336,948 A (LUCIEN) 22 August 1967, entire document.	1 and 2
A	US 4,461,322 A (MILLS) 24 July 1984, entire document.	1 and 2
A	US 4,691,739 A (GOODEN) 08 September 1987, entire document.	1 and 2
A	US 4,997,009 A (NIKURA et al) 05 March 1991, entire document.	1 and 2
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Date of the actual completion of the international search

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